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(54) Tubing collar position sensing apparatus, and associated methods, for use with a snubbing unit.

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Description

The present invention relates to a snubbing apparatus for vertically moving a tubing string according to the pre-characterizing part of claim 1 and to a method of detecting the entry of a tubing string joint into a riser spool. The present invention more particularly provides a snubbing unit having incorporated therein a tubing collar position sensing system which is operative to detect, during upward or downward tubing string travel, the presence and position of each tubing collar between upper and lower blowout preventers, and the vertical movement direction of the collars relative to the blowout preventers.

The typical snubbing unit utilized to vertically move a jointed tubing string into and out of a pressurized well bore moves the tubing string through a stationary riser spool on which vertically spaced upper and lower blowout preventers (BOP's) are operatively mounted. As is well known in this art, the BOP's are used to isolate the interior of the riser spool portion above them (normally at ambient pressure) from the much higher well pressure in the riser spool portion below them, while at the same time being openable and closable in "air lock" fashion to permit sequential passage therethrough of the series of tubing joint collars. Each BOP is sized so that in its closed position it forms a sliding pressure seal around the tubing joint being moved therethrough, and in its open position permits passage therethrough of the larger diameter tubing collar.

During lowering of a particular tubing collar toward the upper BOP, the upper BOP is open, and the lower BOP is closed. When the collar enters the intermediate riser spool portion between the upper and lower BOP's, downward tubing string travel is halted and the upper BOP is closed. The interior of the intermediate riser spool portion is then brought to well pressure by opening an equalizing valve to communicate the intermediate riser spool portion with such well pressure. After this pressure equalization is achieved, the lower BOP is opened, and the tubing string is further lowered to move the collar downwardly past the open lower BOP.

The lower BOP is then closed, and the interior of the intermediate riser spool portion is vented to atmosphere by opening a bleed-off valve operatively connected to the intermediate riser spool portion. The upper BOP is then opened to ready the intermediate riser spool portion for downward receipt of the next tubing collar. A reverse sequence of BOP opening and closing, and pressurization and depressurization of the intermediate riser spool portion interior is, of course, utilized as the tubing string is being moved upwardly through the riser spool by the snubbing unit.

In the snubbing operation just described, it is critically important to temporarily terminate vertical tubing string movement after each tubing collar has entered the intermediate riser spool section through the open BOP, and before the collar strikes the closed BOP, to permit the necessary condition reversal of the BOP's and the pressurization or depressurization of the intermediate riser spool portion interior. Failure to temporarily stop each tubing collar at this position, as is well known, can cause severe disruptions of and lengthy delays in the snubbing operation.

For example, during forcible lifting of the tubing string through the riser spool, if a tubing collar is not stopped upon its upward entry into the intermediate riser spool portion it forcibly strikes the underside of the closed upper BOP. The continuing lifting force on the tubing string above the closed upper BOP can easily tear the tubing string apart at the jammed collar, thereby permitting the entire lower portion of the string to fall to the bottom of the well bore and causing a well blowout through the upper BOP. Also, if the tubing is being forcibly lowered through the riser spool, and a tubing collar strikes the closed lower BOP, the portion of the tubing string above the jammed collar can be easily crumpled and wedged within the riser spool.

The requisite precise positioning, and temporary stoppage, of each vertically successive tubing collar within the intermediate riser spool portion has heretofore been rendered somewhat difficult for two primary reasons. First, after each tubing collar enters the riser spool it can no longer be seen by the snubbing unit operator. Second, there is often at least a slight variation in the collar-to-collar lengths in the tubing string - arising both from tubing joint length variances and variances in the depths to which the joint ends are threaded into their associated collars. Accordingly, it has been previously necessary for the snubbing unit operator to laboriously keep track of each successive collar-to-collar length in the tubing string to facilitate the essentially "blind" placement and stoppage of each collar within the intermediate riser spool portion. A slight calculation error, or an attention lapse by the snubbing unit operator, can thus easily cause breakage or crumpling of the tubing string.

GB-A-2 154 026 discloses an apparatus for controlling the lifting travel on a tubing string having tubing joints interconnected end-to-end by an enlarged diameter tubing collar. An optical sensor is provided for detecting the passage of a tubing joint. An optical sensor cannot be used to detect the tubing collar within a riser spool, since the tubing collar cannot be seen from outside the riser spool.

GB-A-1 602 065 discloses a system for counting tubing joints of a tubing string, wherein sensing means comprise magnetic sensing elements disposed adjacent a bell nipple, a coil being disposed between two longitudinally spaced magnetic elements such that an alteration in the flux produced by said magnetic elements and being due to the passing of a tubular collar is detected. Said coil is not energized or powered. This prior art sensing means can only detect the fact that a tubular collar has past by. However, as outlined above, it is necessary to accurately detect the position of the tubular collar with respect to the blowout preventers.

GB-A-2 132 362 discloses a position sensing apparatus comprising at least two linear variably differential transformers for detecting the position of a longitudinal member in which plural magnetic cores are disposed. The total amount of movement of the member to be detected is in the order of one inch.

The problem underlying the present invention is provide for a snubbing apparatus suitable for correctly positioning and temporarily stopping each successive tubing collar within the intermediate riser spool portion. Moreover, a method of detecting the entry of a tubing string joint into a riser spool is to be provided.

The problem is solved according to the features of the characterizing part of claim 1 and according to the features of claim 19, respectively.

The collar sensing means are associated with the intermediate riser spool portion between the upper and lower BOP's, and are uniquely operative to sense the entry of each tubing collar into the intermediate riser spool portion, its vertical position therein, and its vertical direction of travel therethrough. Output signals, indicative of these positional and directional characteristics of the collars, are generated from the sensing means and permit the snubbing unit operator to continuously and accurately monitor this critical phase of the snubbing operation. The sensing means output signals may also be used in conjunction with collar counter means to monitor and record the total tubing string length which has upwardly or downwardly traversed the intermediate riser spool portion.

The intermediate riser spool portion is, in the present invention, used as a collar sensing spool and is preferably formed from a non-magnetic material such as stainless steel. In a preferred embodiment thereof, the collar sensing means also include upper and lower electric induction coils which outwardly and coaxially circumscribe the sensor spool through which the tubing collars pass.

Electrical frequency generator means are connected to the coils to flow through each of them an electrical current having a predetermined base frequency.

First phase comparator means are interconnected between the upper position sensing coil and the frequency generator means, and are operative to generate a first output signal indicative of the coil power phase alteration corresponding to variation in the degree of vertical proximity between the first coil and a tubing collar vertically traversing the sensor. In a similar fashion, second phase comparator means are interconnected between the frequency generator means and the lower position sensing coil, and are operative to generate a second output signal indicative of the coil power phase alteration corresponding to variation in the degree of vertical proximity between the second coil and the tubing collar.

The first and second output signals are transmitted to position indicating circuit means which compare the two signals and responsively operate collar position and travel direction lights on a suitable control panel, thereby conveniently informing the snubbing unit operator as to when a particular tubing collar enters the sensing spool, where it is in the spool, and in which direction it is moving through the spool.

As a particular downwardly moving tubing collar approaches the upper position sensing coil, the first output signal begins to increase to a maximum value occurring when the collar is vertically centered within the upper coil. Slightly before such centering, an "upper coil" position light on the control panel is illuminated. Further downward collar movement sequentially illuminates a "lower coil" position light on the control panel when the collar is centered between both coils, turns off the "upper coil" light when the collar is centered within the lower coil, and turns off the "lower coil" light as the collar downwardly exits the sensing spool. This sequence is, of course, reversed when a particular tubing collar upwardly traverses the sensing spool.

Incorporated into the position indicating circuitry is a portion which monitors the sequence in which the first and second output signals are brought to their maximum values, and responsively illuminates an "up" or "down" light on the control panel to indicate to the snubbing unit operator the vertical direction of collar travel through the sensing spool. In this manner the operator is provided with precise information regarding collar entry, position and travel direction, thereby eliminating the previous necessity of keeping track of each collar-to-collar tubing string length.

The position indicating circuitry may be augmented, if desired, as an optional feature of the present invention to automatically provide tubing string movement lockout if the BOP's are not in their proper open or closed positions, and also to provide such movement lockout when each tubing

collar becomes vertically centered between the upper and lower position sensing coils. As a further optional feature of the present invention, additional useful system condition information may be incorporated into the control panel by outputting to the control panel position signals from the levers used to hydraulically operate the BOP's and the bleed-off and equalizing valves, and riser spool pressure signals from above, within and below the sensing spool, to operate condition lights positioned on the control panel and indicating whether each of the BOP's, and the bleed-off and equalizing valves is open or closed.

While in the preferred embodiment of the present invention two vertically stacked position sensing coils are utilized, a greater or lesser number of such coils could be used if desired. For example, if a somewhat simpler collar entry-and-position only system is desired, a single position sensing coil could be used. On the other hand, if somewhat greater collar position sensing accuracy is desired, one or more additional position sensing coils could be used.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a vertically foreshortened, somewhat schematic perspective view of a snubbing unit which incorporates therein a tubing collar position sensing system embodying principles of the present invention;

FIG. 2 is a schematic diagram, partially in cross-section, of the collar position sensing system together with associated control and position indicating circuitry;

FIGS. 3A-3C are schematic cross-sectional views through a sensing spool portion of the collar position sensing system, and sequentially illustrate three representative positions of a tubing collar as it is passed downwardly through the sensing spool; and

FIGS. 4A and 4B, collectively, are a schematic logic diagram illustrating representative control and safety circuitry which may optionally be incorporated in a microprocessor portion of the collar position sensing system.

Referring initially to Figs. 1-3A, the present invention provides a snubbing unit 10 (Fig. 1) which is utilized to vertically move a tubing string 12 into and out of a well bore (not illustrated) through a vertically disposed riser spool 14. Except for features of the present invention incorporated therein and described below, the snubbing unit 10 is of a generally conventional construction and includes an elevated operator platform 16, positioned above the upper end of the riser spool 14, and the usual tubing string lifting and lowering structure including upper and lower slip bowl assemblies 18 and 20.

The tubing string 12 is formed from a series of metal tubing joints 22 which are threadedly interconnected end-to-end by a series of internally threaded, larger diameter metal tubing collars 24, only one of which is illustrated in the drawings. Vertically spaced upper and lower blowout preventers 26 and 28 are operatively installed in the riser spool 14 at opposite ends of an intermediate riser spool section 14_a which, as later described, functions as a collar position sensing spool and is formed from a nonmagnetic material, preferably stainless steel.

A pressure bleed line 30, having a bleed-off valve 32 installed therein, is connected to the intermediate riser spool section 14_a and communicates with its interior. Additionally, the interiors of the intermediate riser spool section 14_a and a portion of the riser spool disposed beneath the lower blowcut preventer 28 are intercommunicated through a pressure equalizing line 34 in which an equalizing valve 36 is operatively installed.

As schematically illustrated in Fig. 2, the upper and lower blowout preventers 26 and 28, the bleed-off valve 32, and the equalizing valve 36 are selectively openable and closable by means of hydraulic line sets 26_a, 28_a, 32_a, and 36_a which are respectively provided with associated operator control handles 26_b, 28_b, 32_b, and 36_b. For purposes later described, pressure sensing lines 38, 40 and 42 are provided with associated pressure gauges 38_a, 40_a and 42_a, and are respectively communicated with the interior of a riser spool portion above the upper blowout preventer, the intermediate riser spool section 14_a, and a portion of the riser spool disposed beneath the lower blowout preventer.

In a conventional fashion, the upper and lower blowout preventers 26, 28 are individually closable to form sliding pressure seals around a tubing joint portion of the tubing string 12, and are individually openable to permit axial passage of the larger diameter tubing collar 24 therethrough.

As the tubing string 12 is, for example, being lowered through the riser spool 14 into the well bore and the tubing collar 24 is downwardly approaching the upper blowout preventer 26 (Fig. 2), the upper blowout preventer 26 is open, and the lower blowout preventer 28 is closed. Upon entry of the tubing collar 24 into the intermediate riser spool section 14_a (Figs. 3A and 3B , further downward movement of the tubing string 12 is temporarily halted (Fig. 3B) and the upper blowout preventer 26 is closed. The equalizing valve 36 (Fig. 2) is then opened to controllably elevate the pressure within the intermediate riser spool section 14_a to that of the well pressure.

Next, the lower blowout preventer 28 is opened, and downward tubing string movement is resumed (Fig. 3C) to pass the tubing collar 24

downwardly through the now-opened lower blowout preventer 28. When the tubing collar 24 has downwardly passed the lower blowout preventer, the lower blowout preventer is closed, and the bleed-off valve 32 (Fig. 2) is opened to vent the interior of the intermediate riser section 14_a to atmospheric pressure. Finally, the upper blowout preventer 26 is again opened to ready the system for the vertical movement of another tubing joint 22 and collar 24 through the intermediate riser spool section 14a. This described sequence of the opening and closing of the blowout preventers and the bleed-off and the equalizing valves is, of course, reversed when the tubing string 12 is being moved upwardly through the riser spool 14.

In the snubbing operation just described, upon entry of a tubing collar 24 into the intermediate riser spool section 14_a through an opened blowout preventer, it is critically important that the tubing collar be stopped before it forcibly strikes the closed blowout preventer which it is approaching. For example, if the tubing string 12 is being forcibly driven downwardly through the riser spool and is permitted to strike the closed lower blowout preventer, a portion of the tubing string above the collar can easily be crumpled and wedged within the riser spool. If, on the other hand, the tubing string is being forcibly lifted through the riser spool and the collar strikes the closed upper blowout preventer, the tubing string can easily be ripped apart at the jammed collar, thereby creating a blowout condition and permitting a lower tubing string portion to fall into the well bore.

Despite the criticality of stopping each tubing collar within the intermediate riser spool section 14_a to prevent the entering collar from striking the enclosed blowout preventer, in conventional snubbing operations this collar stoppage is not always reliably effected. This is due to the fact that the collars entering and traversing the intermediate riser spool section 14_a cannot be seen by the snubbing unit operator. Accordingly, proper placement and stoppage of each collar within the intermediate riser spool section has heretofore been accomplished by keeping track of the collar-to-collar distance of each tubing joint 22.

However, as is well known, these lengths tend to vary since the tubing joints are usually field cut, and the distance into its collar which each tubing joint is threaded can also vary. Accordingly, a slight measurement inaccuracy, or a mental lapse on the part of the snubbing unit operator could heretofore cause undesirable forcible contact between a tubing collar and a closed blowout preventer.

In the present invention, however, this potentially serious problem is effectively eliminated by the provision of a unique collar position sensing system 50 (Fig. 2) which, as will be seen, detects and indicates the entry of a tubing collar 24 into the intermediate riser spool section 14_a, the vertical position of the tubing collar within the riser spool section, and the vertical direction of travel of the tubing collar through the intermediate riser spool section. Accordingly, the sensing system 50 of the present invention permits the snubbing unit operator to reliably and precisely position and stop each successive tubing collar 24 within the intermediate riser spool section 14_a irrespective of variations in collar-to-collar tubing string lengths and without the previous necessity of measuring and remembering such differing lengths.

In the illustrated preferred embodiment thereof, the collar position sensing system 50 includes the intermediate riser spool section 14a which is used as a position sensing spool and is formed from a nonmagnetic material, preferably stainless steel. Secured to and coaxially circumscribing a longitudinally central portion of the riser spool section 14_a are schematically depicted upper and lower electric induction coils 52 and 54. Comparator circuit means 56 are operatively associated with the upper and lower electric induction coils 52 and 54, and include a frequency generator 58 and a pair of phase comparators 60 and 62.

The frequency generator 58 is operative to supply electrical power to the upper and lower induction coils 52, 54 via leads 64, 66 and 68, and is additionally interconnected as shown with the phase comparators 60, 62 by leads 70, 72 and 74. Additionally, the phase comparator 60 is connected to the upper induction coil 52 by a lead 76, and the phase comparator 62 is connected to the lower induction coil 54 by a lead 78.

With each of the induction coils 52, 54 energized by the frequency generator 58, and the tubing string 12 being vertically moved through the riser spool 14 (for example in the downward direction representatively illustrated in Fig. 2), the phase comparators 60, 62 are respectively operative to detect power phase shifts at the induction coils, attributable to variations in the vertical position of the tubing collar 24 relative to the coils, and responsively generate output signals 80 and 82 which are respectively indicative of the power phase shifts at coils 52 and 54. The output signals 80, 82 are transmitted to a position sensing circuit portion 84 of a control panel 86, and are combinatively indicative of collar entry into riser spool section 14_a, the vertical position of the collar in riser spool section 14_a, and the direction of vertical travel of the collar through riser spool section 14a. Position sensing circuit 84 may optionally be incorporated into a suitable microprocessor if desired.

With the tubing collar 24 positioned above the spool section 14_a (Fig. 2), and only a portion of a tubing joint 22 disposed therein, the power phase

shift at each coil 52, 54 (compared to the power phases at each coil with the tubing string withdrawn from the intermediate riser spool section) are essentially equal, as are the strengths of the output signals 80, 82. However, when the tubing collar 24 downwardly enters the intermediate riser spool section 14_a and closely approaches the upper coil 52 the output signal 80 begins to increase due to the increase in power phase shift at the upper coil 52. As the tubing collar 24 approaches its generally centered position relative to the upper coil 52 (Fig. 3A) the strength of the output signal 80 increases relative to the output signal 82. When the output signal 80 is increased to a predetermined magnitude, the position sensing circuit 84 operates to illuminate an "upper coil" light 88 on the control panel 86, thereby visually indicating to the snubbing unit operator that the tubing collar 24 has downwardly entered the intermediate riser spool section 14_a.A corresponding audible collar entry signal may also be generated through a speaker or horn portion 90 on the control panel 86.

As the tubing collar 24 is moved downwardly from its Fig. 3A to its Fig. 3B position, in which the collar is generally vertically centered between the upper and lower coils 52 and 54, the phase shift output signal 80 decreases, and the strength of the phase shift output signal 82 increases until the signals 80, 82 are equalized. At this time, the circuit 84 additionally illuminates a "lower coil" light 92 on the control panel 86, indicating to the snubbing unit operator that the tubing collar 24 is vertically centered within the intermediate riser spool section 14_a, and it is time to temporarily stop downward tubing string travel to permit the previously described sequencing of the blowout preventers, the bleed-off valve and the equalizing valve to permit movement of the collar 24 through the lower blowout preventer 28.

When the lower blowout preventer 28 is subsequently opened, the tubing collar 24 is moved downwardly from its coil-centered Fig. 3B position as indicated in Fig. 3C in which the collar is generally centered relative to the lower coil 54. When the collar is generally centered in this manner relative to the lower coil, the power phase shift at the upper coil, and the strength of the output signal 82, have been decreased, and the strength of output signal 80 has been increased to an extent such that the circuit 84 turns off the upper coil light 88 so that only the lower coil light 92 is still illuminated. This indicates to the snubbing unit operator that the collar 24 is in a lower portion of the intermediate riser spool section 14_a and has downwardly passed the upper coil. Further downward movement of the tubing collar outwardly through the opened lower blowout preventer 28 progressively decreases the strength of output signal 80 until, with the collar moved downwardly passed the lower blowout preventer, the lower coil light 92 is also turned off. This indicates to the snubbing unit operator that the collar has completely exited the intermediate riser spool section 14_a.

The downward traversal of each of the coils 52, 54 by the collar 24, via the circuit 84, incrementally advances a counter portion 92 of the control panel 86 to give to the snubbing unit operator a running visual indication of the total number of collars which have been passed downwardly through the riser spool section 14_a. The total number of such collar passages may be conveniently recorded for future reference on an optional recorder portion 94 of the control panel 86.

A representative flow diagram of the circuit 84 incorporated in the control panel 86 is illustrated in Figs. 4A and 4B. It can be seen in such flow diagram that the circuit 84 may be utilized, via the use of upper and lower sensor "flags", to compare the time sequence of the energizations of the upper and lower coil lights 88 and 92 to thereby energize a "down" direction light 96 on the control panel to indicate to the operator that the collar 24 is moving downwardly through the riser spool section 14_a. As will be appreciated, the sequence in which the lights 88, 92 are illuminated will be reversed when the tubing string 12 is being moved upwardly through the riser spool 14, and corresponding circuitry may be employed to illuminate an "up" direction light 98 when the tubing string is being moved upwardly through the sensing collar.

In addition to these collar entry, position, and direction indicating functions provided by the circuit 84, the circuit may optionally be designed (as illustrated in Figs. 4A and 4B) to include a safety circuit portion which is operative to prevent opening of either of the blowout preventers in the event that pressure conditions in the intermediate spool section 14_a are not correct, and to generate a lockout signal usable to temporarily prevent further downward tubing movement through the riser spool after a tubing collar has become centered therein. The flow diagram illustrated in Figs. 4A and 4B represents the circuitry portion used during downward tubing string movement. It will be appreciated that a corresponding, but operationally reversed, circuit may be utilized during upward tubing string movement.

As a further optional feature of the present invention, to further assist the operator in monitoring the operation of the snubbing unit, handle position indicating signals 100, 102, 104 and 106 from the operating handles 26_b, 28_b, 32_b and 36_b, and pressure signals 108, 110 and 112 from the pressure sensing lines 38, 40 and 42 may be appropriately transmitted to the control panel 86. Additional circuitry in the control panel may then be

used to appropriately combine such signals and responsively energize open/closed light sets 114, 116, 118 and 120 respectively indicating the open/closed positions of the upper blowout preventer, the lower blowout preventer, the equalizing valve, and the bleed-off valve. These open/closed light sets may be conveniently positioned on an optional portion 86_a of the control panel 86.

While the sensing system 50 of the present invention is particularly well suited for use in the representatively illustrated snubbing unit 10, it may also be advantageously utilized in a variety of other wellbore-related applications in which it is desirable to accurately sense (via a detectable mass differential) the vertical position of a selected longitudinal portion of an elongated structure being raised out of or lowered into a well bore. As but one example, the sensing system could be used in wireline operations to indicate when the wireline tool string is fully up into the lubricator.

The foregoing detailed description is to be clearly understood as being given by way of illustration and example only, the scope of the present invention being limited solely by the appended claims.

Claims

1. Snubbing apparatus for vertically moving a tubing string (12) into and out of a well bore, the tubing string including a duality of elongated tubing joints (22) interconnected end-to-end by a enlarged diameter tubing collar (24), said snubbing apparatus comprising:

   a vertically extending riser spool (14) through which the tubing string (12) may be axially moved into and out of the well bore;

   vertically spaced upper and lower blowout preventers (26,28) operatively mounted on said riser spool at opposite ends of a longitudinal section (14a) thereof, each of said upper and lower blowout preventers being individually closable to form a sliding pressure seal around a tubing joint portion of the tubing string, and individually openable to permit axial passage of the tubing collar (24) therethrough;

   means for selectively moving the tubing string upwardly or downwardly through said riser spool, characterized in that:

   sensing means (50) comprising a electric induction coil means (52,54) is operatively mounted on said riser spool section, for detecting the entry of the tubing collar (24) into said riser spool section through an opened one of said upper and lower blowout preventers, and responsively generating an output signal (80,82) indicative of said entry, so that further vertical movement of the tubing string may be reliably terminated prior to contact between the tubing collar (24) and the closed other one of said upper and lower blowout preventers.

2. The snubbing apparatus of Claim 1 characterized in that:

   said sensing means (50) are further operative to detect the vertical position of the tubing collar (24) within said riser spool section (14a) and responsively generate an output signal (80,82) indicative of said vertical position.

3. The snubbing apparatus of Claim 1 or 2 characterized in that:

   said sensing means (50) are further operative to detect the direction of vertical movement of the tubing collar (24) through said riser spool section (14a) and responsively generate an output signal (80,82) indicative of said direction of vertical movement.

4. The snubbing apparatus of Claim 1 further characterized in that said sensing means includes:

   circuit means (56) for supplying electrical power to said electric induction coil means (52,54) at a predetermined frequency, detecting variations in the supplied electrical power attributable to variations in the vertical position of the tubing collar (24) relative to said electric induction coil means, and responsively generating an output signal means (80,82) indicating the entry of the tubing collar into said riser spool section.

5. The snubbing apparatus of Claim 4 characterized in that said output signal means (80,82) are further indicative of the vertical position of the tubing collar (24) within said riser spool section (14a) and responsively generate a output signal (84) indicative of said vertical position.

6. The snubbing apparatus of Claim 4 or 5 characterized in that said output signal means (80,82) are further indicative to detect the direction of vertical movement of the tubing collar (24) through said riser spool section (14a) and responsively generate a output signal (96,98) indicative of said direction of vertical travel.

7. The snubbing apparatus of any one of Claims 4 to 6 characterized in that:

   said electric induction coil (52,54) means include a plurality of electric induction coils each positioned on a different axial portion of said riser spool section.

8. The snubbing apparatus of any one of Claims 4 to 7 characterized in that:

said circuit means (56) are operative to detect phase shifts in the electric power supplied to said electric induction coil means (52,54), said phase shifts being occasioned by variations in the axial proximity of said collar (24) to said electric induction coil means.

9. The snubbing apparatus of any one of Claims 4 to 8 characterized in that said circuit means include:

frequency generator means (58) connected to said electric induction coil means for supplying said electrical power thereto, and

phase comparator means (60,62), interconnected between said frequency generator means (58) and said electric induction coil means, for detecting supplied electrical power phase shifts and responsively generating output signals (80,82) combinatively indicative of the entry of the tubing collar (24) into said riser spool section (14a), the vertical position of the tubing collar within said riser spool section, and the direction of vertical travel of the tubing collar through said riser spool section.

10. The snubbing apparatus of Claim 4 characterized in that:

said electric induction coil means include a first electric induction coil (52) outwardly circumscribing said riser spool section, and a second electric induction coil (54) outwardly circumscribing said riser spool section and positioned below said first electric induction coil.

11. The snubbing apparatus of Claim 10 characterized in that: said riser spool section (14a) is of an essentially non-magnetic material.

12. The snubbing apparatus of Claim 11 characterized in that: said riser spool section (14a) is of a stainless steel material.

13. The snubbing apparatus of Claim 4 further characterized in that it comprises:

safety circuit means (Fig. 4A,-B) for generating a lockout signal in response to entry of the tubing collar (24) into said riser spool section, said lockout signal being usable to automatically disable said means for selectively moving the tubing string.

14. The snubbing apparatus of Claim 13 characterized in that:

said safety circuit means (Fig. 4A,-B) are further operative to sense the open/closed condition of each of said upper and lower blowout preventers (26,28) and generate a lockout signal usable to disable said means for selectively moving the tubing string (12) in the event that either of said upper and lower blowout preventers is in an improper open/closed condition.

15. The snubbing apparatus of Claims 13 or 14 characterized in that:

said snubbing apparatus further comprises a bleed-off valve (32) connected to said riser spool section (14a) and operable to vent the interior thereof to atmospheric pressure, and an equalizing line (34) interconnected between said riser spool section and a portion of said riser spool (14) positioned below said lower blowout preventer, said equalizing line having a equalizing valve (36) positioned therein and operable to selectively bring the interior of said riser spool section to well pressure, and

said safety circuit means (Fig. 4A,-B) are further operative to sense the open/closed condition of each of said bleed-off valve (32) and said equalizing valve (34) and generate a lockout signal usable to disable said means for selectively moving the tubing string (12) in the event that either of said bleed-off valve and said equalizing valve is in an improper open/closed condition.

16. The snubbing apparatus of any one of Claims 1 to 4 further characterized in that it further comprises:

means (84,92) for sensing and recording the number of tubing collars (24) traversing said riser spool section in a given vertical direction, whereby the length of the tubing string (12) disposed beneath said lower blowout preventer may be accurately monitored.

17. The snubbing apparatus of any one of Claims 1 to 4 characterized in that it further comprises:

a bleed-off valve (32) connected to said riser spool section and operable to vent thereof to atmospheric pressure,

an equalizing line (34) intercommunicating the interiors of said riser spool section and a portion of said riser spool (14) disposed beneath said lower blowout preventer,

an equalizing valve (36) positioned in said equalizing line and operable to selectively elevate the pressure within said riser spool section to that of the well bore, and

means (86) for providing a remote visual indication of the open/closed conditions of said upper and lower blowout preventers, said bleed-off valve and said equalizing valve.

18. The snubbing apparatus of Claim 17 characterized in that:

said upper and lower blowout preventers, said bleed-off valve and said equalizing valve are each hydraulically operated by handle means (26b,28b,32b,36b), and

said means for providing a remote visual indication include means (100-106) for sensing the position of each of said handle means, means (108-112) for sensing the internal pressures of said riser spool section, a portion of said riser spool disposed above said upper blowout preventer (26), and a portion of said riser spool disposed below said lower blowout preventer (28).

19. A method of detecting the entry of a tubing string joint connecting collar (24) into a longitudinal section (14a) of a riser spool (14) disposed between upper and lower blowout preventers (26,28) during axial tubing string movement through the riser spool, said method comprising the steps of:

securing an electric induction coil (52,54) to the longitudinal riser spool section (14a) between the upper and lower blowout preventers (26,28);

supplying electrical power (64) to said electric induction coil;

causing the tubing collar (24), as it enters said longitudinal riser spool section (14a), to create a phase shift in said electrical power; and

detecting said phase shift and responsively generating a output signal (80,82) indicative thereof.

20. The method of Claim 19 further characterized in that

the step of securing an electric induction coil to the longitudinal riser spool section includes the step of securing upper (52) and lower (54) electric induction coils to the riser spool section (14a) between the upper and lower blowout preventers (26,28) and supplying electrical power to said electric induction coils; and

said step of detecting said phase shift includes detecting phase shifts (60,62) from each of said electric induction coils (52,54) and responsively generating output signals (80,82) combinatively indicative of the entry of the tubing collar (24) into the riser spool section (14a), the vertical position of the tubing collar (24) within the riser spool section (14a), and the direction of vertical travel of the tubing collar (24) through the riser spool section (14a).

Patentansprüche

1. Druckeinbauvorrichtung zum vertikalen Bewegen eines Rohrstrangs (12) in ein Bohrloch hinein und aus diesem heraus, wobei der Rohrstrang ein Paar aus langgestreckten Rohrschüssen (22) aufweist, die endseitig über einen einen vergrößerten Durchmesser aufweisenden Rohrbund (24) verbunden sind, wobei die Druckeinbauvorrichtung aufweist:

eine sich vertikal erstreckende Steigtrommel (14) durch die hindurch der Rohrstrang (12) axial in das Bohrloch hinein und aus ihm heraus bewegbar ist;

ein oberes und ein unteres Sicherheitsventil (26,28), die vertikal beabstandet sind und an einander abgewandten Enden eines Längsabschnitts (14a) der Steigtrommel gelagert sind, wobei jedes von dem oberen und dem unteren Sicherheitsventil individuell schließbar ist, um eine Gleitdruckdichtung um einen Rohrschußabschnitt des Rohrgestänges herum zu bilden, und individuell öffenbar ist, um einen axialen Durchlauf des Rohrbundes (24) durch das Ventil hindurch zu ermöglichen;

eine Einrichtung zum selektiven Bewegen des Rohrgestänges durch die Steigtrommel hindurch nach oben oder nach unten,

dadurch gekennzeichnet, daß

an dem Steigtrommelabschnitt eine Sensoreinrichtung (50) gelagert ist, die eine elektrische Induktionsspulenanordnung (52,54) aufweist, um den Eintritt des Rohrbundes (24) in den Steigtrommelabschnitt durch ein geöffnetes Sicherheitsventil von dem oberen und dem unteren Sicherheitsventil hindurch zu erfassen, und um darauf ansprechend ein für den Eintritt kennzeichnendes Ausgangssignal (80,82) zu erzeugen, so daß eine weitergehende Vertikalbewegung des Rohrgestänges zuverlässig beendet werden kann, bevor es zu einer Berührung zwischen dem Rohrbund (24) und dem geschlossenen Sicherheitsventil von dem oberen und dem unteren Sicherheitsventil kommt.

2. Druckeinbauvorrichtung nach Anspruch 1,

dadurch gekennzeichnet, daß

die Sensoreinrichtung (50) dazu ausgebildet ist, die vertikale Lage des Rohrbundes (24) innerhalb des Steigtrommelabschnitts (14a) zu erfassen und darauf ansprechend ein Ausgangssignal (80,82) zu erzeugen, welches kennzeichnend für die vertikale Lage ist.

3. Druckeinbauvorrichtung nach Anspruch 1 oder 2,

dadurch gekennzeichnet daß,

die Sensoreinrichtung (50) weiterhin dazu aus-

gebildet ist, die Richtung der Vertikalbewegung des Rohrbundes (24) durch den Steigtrommelabschnitt (14a) zu erfassen und ansprechend darauf ein Ausgangssignal (80,82) zu erzeugen, welches kennzeichnend für die Richtung der Vertikalbewegung ist.

4. Druckeinbauvorrichtung nach Anspruch 1, **dadurch gekennzeichnet**, daß die Sensoreinrichtung aufweist: Eine Schaltungseinrichtung (56) zum Zuführen elektrischer Leistung zu der elektrischen Induktionsspulenanordnung (52,54) bei einer vorbestimmten Frequenz, zum Erfassen von Schwankungen der zugeführten elektrischen Leistung, verursacht durch Schwankungen in der vertikalen Lage des Rohrbundes (24) relativ zu der elektrischen Induktionsspulenanordnung, um darauf ansprechend Ausgangssignalmittel (80,82) zu erzeugen, die kennzeichnend sind für den Eintritt des Rohrbundes in den Steigtrommelabschnitt.

5. Druckeinbauvorrichtung nach Anspruch 4, **dadurch gekennzeichnet**, daß die Ausgangssignalmittel (80,82) außerdem kennzeichnend sind für die vertikale Lage des Rohrbundes (24) innerhalb des Steigtrommelabschnitts (14a), um ansprechend darauf ein Ausgangssignal (84) zu erzeugen, welches kennzeichnend für die vertikale Lage ist.

6. Druckeinbauvorrichtung nach Anspruch 4 oder 5, **dadurch gekennzeichnet**, daß die Ausgangssignalmittel (80,82) weiterhin dazu dienen, die Richtung der Vertikalbewegung des Rohrbundes (24) durch den Steigtrommelabschnitt (14a) zu erfassen, um ansprechend darauf ein Ausgangssignal (96,98) zu erzeugen, welches kennzeichnend für die Richtung der Vertikalbewegung ist.

7. Druckeinbauvorrichtung nach jedem der Ansprüche 4 bis 6, **dadurch gekennzeichnet**, daß die elektrische Induktionsspulenanordnung (52,54) mehrere elektrische Induktionsspulen aufweist, von denen sich jede an einem unterschiedlichen axialen Abschnitt des Steigtrommelabschnitts befindet.

8. Druckeinbauvorrichtung nach jedem der Ansprüche 4 bis 7, **dadurch gekennzeichnet**, daß die Schaltungseinrichtung (56) dazu ausgelegt ist, Phasenverschiebungen der der elektrischen Induktionsspulenanordnung (52,54) zugeführten elektrischen Leistung zu erfassen, wobei die Phasenverschiebungen hervorgerufen werden durch Schwankungen der axialen Entfernung des Bundes (24) bezüglich der elektrischen Induktionsspulenanordnung.

9. Druckeinbauvorrichtung nach jedem der Ansprüche 4 bis 8, **dadurch gekennzeichnet**, daß die Schaltungseinrichtung aufweist: eine Frequenzgeneratoreinrichtung (58), welche an die elektrische Induktionsspulenanordnung angeschlossen ist, um dieser elektrische Leistung zuzuführen, und eine Phasenvergleichereinrichtung (60,62), die zwischen die Frequenzgeneratoreinrichtung (58) und die elektrische Induktionsspulenanordnung geschaltet ist, um Phasenverschiebungen der zugeführten elektrischen Leistung zu erfassen und ansprechend darauf Ausgangssignale (80,82) zu erzeugen, die in Kombination kennzeichnend sind für den Eintritt des Rohrbundes (24) in den Steigtrommelabschnitt (14a), die vertikale Lage des Rohrbundes innerhalb des Steigtrommelabschnitts, und die Richtung der Vertikalbewegung des Rohrbundes durch den Steigtrommelabschnitt.

10. Druckeinbauvorrichtung nach Anspruch 4, **dadurch gekennzeichnet**, daß die elektrische Induktionsspulenanordnung eine erste elektrische Induktionsspule (52), welche den Steigtrommelabschnitt außen umgibt, und eine zweite elektrische Induktionsspule (54), die den Steigspulenabschnitt außen umgibt und unterhalb der ersten elektrischen Induktionsspule angeordnet ist, aufweist.

11. Druckeinbauvorrichtung nach Anspruch 10, **dadurch gekennzeichnet**, daß der Steigtrommelabschnitt (14a) aus einem im wesentlichen nichtmagnetischem Material besteht.

12. Druckeinbauvorrichtung nach Anspruch 11, **dadurch gekennzeichnet**, daß der Steigtrommelabschnitt (14a) aus einem rostfreien Stahl besteht.

13. Druckeinbauvorrichtung nach Anspruch 4, **dadurch gekennzeichnet**, daß sie weiterhin aufweist: Eine Sicherheitsschaltungseinrichtung (**Fig. 4A,-B**) zum Erzeugen eines Sperrsignals in Abhängigkeit des Eintritts des Rohrbundes (24) in den Steigtrommelabschnitt, wobei das Sperrsignal dazu verwendbar ist, die Einrichtung zum selektiven Bewegen des Rohrstrangs

automatisch außer Betrieb zu setzen.

14. Druckeinbauvorrichtung nach Anspruch 13, **dadurch gekennzeichnet**, daß die Sicherheitsschaltungseinrichtung **(Fig. 4A,-B)** weiterhin dazu ausgelegt ist, den geöffneten/geschlossenen Zustand sowohl des oberen als auch des unteren Sicherheitsventils (26,28) zu erfassen und ein Sperrsignal zu erzeugen, welches dazu benutzbar ist, die Einrichtung zum selektiven Bewegen des Rohrstrangs (12) für den Fall zu deaktivieren, daß entweder das obere oder das untere Sicherheitsventil sich in einem nicht richtig geöffneten/geschlossenen Zustand befindet.

15. Druckeinbauvorrichtung nach Anspruch 13 oder 14, **dadurch gekennzeichnet**, daß die Druckeinbauvorrichtung außerdem aufweist: Ein Entlüftungsventil (32), das an den Steigtrommelabschnitt (14a) angeschlossen ist und dazu dient, das Innere des Steigtrommelabschnitts auf Atmosphärendruck zu entlüften, und eine Ausgleichsleitung (34) die zwischen dem Steigtrommelabschnitt und einem Abschnitt der Steigtrommel (14) unterhalb des unteren Sicherheitsventils angeschlossen ist, wobei die Ausgleichsleitung ein Ausgleichsventil (36) beinhaltet, mit dessen Hilfe das Innere des Steigtrommelabschnitts selektiv auf Bohrlochdruck bringbar ist, und die Sicherheitsschalteinrichtung **(Fig. 4A,-B)** außerdem dazu ausgelegt ist, den offenen/geschlossenen Zustand sowohl des Entlüftungsventils (32) als auch des Ausgleichventils (34) zu erfassen und ein Sperrsignal zu erzeugen, welches dazu dient, die Einrichtung zum selektiven Bewegen des Rohrstrangs (12) für den Fall zu deaktivieren, daß entweder das Entlüftungsventil oder das Ausgleichsventil sich in einen nicht richtig geöffneten/geschlossenen Zustand befindet.

16. Druckeinbauvorrichtung nach jedem der Ansprüche 1 bis 4, weiterhin **gekennzeichnet durch**: Eine Einrichtung (84,92) zum Erfassen und Aufzeichnen der Anzahl von Rohrbündeln (24), welche den Steigtrommelabschnitt in einer gegebenen vertikalen Richtung passieren, wobei die Länge des Rohrstrangs (12), die sich unterhalb des unteren Sicherheitsventils befindet, genau überwachbar ist.

17. Druckeinbauvorrichtung nach jedem der Ansprüche 1 bis 4, **gekennzeichnet durch**: Ein Entlüftungsventil (32), welches an den Steigtrommelabschnittangeschlossen ist und dazu dient, diesen auf Atmosphärendruck zu entlüften, eine Ausgangsleitung (34), die mit dem Inneren des Steigtrommelabschnitts und einem Abschnitt der Steigtrommel (14) unterhalb des unteren Sicherheitsventils verbunden ist, ein Ausgangsventil (36), welches sich in der Ausgleichsleitung befindet und dazu dient, den Druck innerhalb des Steigtrommelabschnitts auf den des Bohrlochs selektiv anzuheben, und eine Einrichtung (86) zur Ermöglichung einer Fernsichtanzeige des geöffneten/geschlossenen Zustands des oberen und des unteren Sicherheitsventils, des Entlüftungsventils und des Ausgleichventils.

18. Druckeinbauvorrichtung nach Anspruch 17, **dadurch gekennzeichnet**, daß das obere und das untere Sicherheitsventil, das Entlüftungsventil und das Ausgleichsventil jeweils mit Hilfe einer Handhabe (26b,28b,32b,36b) hydraulisch betätigt werden, und die Einrichtung zum Ermöglichen einer Fernsichtanzeige Mittel (100-106) aufweist zum Erfassen der Position jeder Handhabe, einer Einrichtung (108-112) zum Erfassen des Innendrucks des Steigtrommelabschnitts, eines Abschnitts der Steigtrommel oberhalb des oberen Sicherheitsventils (26), und eines Abschnitts der Steigtrommel unterhalb des unteren Sicherheitsventils (28).

19. Verfahren zum Feststellen des Eintritts eines Rohrstrangschuß-Verbindungsbundes (24) in einen sich zwischen einem oberen und einem unteren Sicherheitsventil (26,28) befindlichen Längsabschnitt (14a) einer Steigtrommel (14) während der axialen Rohrstrangbewegung durch die Steigtrommel hindurch, **gekennzeichnet durch** die Schritte: Anordnen einer elektrischen Induktionsspule (52,54) an den Längsabschnitt (14a) der Steigtrommel zwischen dem oberen und dem unteren Sicherheitsventil (26,28); Zuführen elektrischer Leistung (64) zu der elektrischen Induktionsspule; Veranlassen, daß der Rohrbund (24) beim Eintreten in den Längsabschnitt (14a) der Steigtrommel eine Phasenverschiebung der elektrischen Leistung hervorruft; und Feststellen der Phasenverschiebung und, abhängig davon, Erzeugen eines dafür kennzeichnenden Ausgangssignals (80,82).

20. Verfahren nach Anspruch 19, **dadurch gekennzeichnet**, daß der Schritt des Anbringens einer elektrischen Induktionsspule an den Längsabschnitt der Steigtrommel den Schritt des Anbringens einer oberen (52) und einer unteren (54) elektrischen Induktionsspule an dem Steigtrommelabschnitt (14a) zwischen dem oberen und dem unteren Sicherheitsventil (26,28) und des Zuführens elektrischer Leistung zu den elektrischen Induktionsspulen umfaßt; und der Schritt des Feststellens der Phasenverschiebung das Erfassen von Phasenverschiebungen (60,62) aus jeder der elektrischen Induktionsspulen (52,54) umfaßt, sowie das davon abhängige Erzeugen von Ausgangssignalen (80,82), die kombiniert kennzeichnend sind für den Eintritt des Rohrbundes (24) in den Steigtrommelabschnitt (14a), die vertikale Lage des Rohrbundes (24) innerhalb des Steigtrommelabschnitts (14a) und die Richtung der Vertikalbewegung des Rohrbundes (24) durch den Steigtrommelabschnitt (14a).

Revendications

1. Appareil d'amarrage destiné à déplacer verticalement un train de tiges (12) vers l'intérieur et l'extérieur d'un puits, le train de tiges comprenant deux ensembles de joints allongés (22) de tiges raccordés bout à bout par un collier de diamètre agrandi (24), l'appareil d'amarrage comprenant :

un raccord vertical (14) de colonne montante dans lequel le train de tiges (12) peut être déplacé axialement lorsqu'il est introduit dans le sondage et retiré de celui-ci,

des vannes supérieure et inférieure d'éruption (26, 28) espacées verticalement et montées sur le raccord de colonne montante à des extrémités opposées d'un tronçon longitudinal (14a) de celles-ci, chacune des vannes supérieure et inférieure d'éruption pouvant être fermée individuellement pour la formation d'un joint glissant sous pression autour d'une partie de raccord du train de tiges et pouvant être ouverte individuellement pour permettre le passage axial du collier de train de tiges (24),

un dispositif de déplacement sélectif du train de tiges vers le haut et vers le bas dans le raccord de colonne, caractérisé en ce que :

un dispositif de détection (50) comprenant un dispositif à bobines d'induction électrique (52, 54) est monté lors du fonctionnement sur le tronçon de raccord de colonne afin qu'il détecte l'entrée du collier de tube (24) dans le tronçon de colonne par la vanne supérieure ou inférieure d'éruption qui est ouverte, et qu'il crée, en conséquence un signal de sortie (80, 82) qui est représentatif de cette entrée, si bien que le déplacement vertical du train de tiges peut être interrompu de manière fiable avant contact entre le collier (24) et l'autre des vannes supérieure et inférieure d'éruption qui est fermée.

2. Appareil d'amarrage selon la revendication 1, caractérisé en ce que :

le dispositif de détection (50) est destiné en outre à détecter la position verticale du collier (34) à l'intérieur du tronçon de raccord de colonne (14a) et à créer en conséquence un signal de sortie (80, 82) qui dépend de la position verticale.

3. Appareil d'amarrage selon la revendication 1 ou 2, caractérisé en ce que :

le dispositif de détection (50) est en outre destiné à détecter la direction de déplacement vertical du collier (24) dans le tronçon de raccord de colonne (14a) et à créer en conséquence un signal de sortie (80, 82) qui est représentatif du sens de déplacement vertical.

4. Appareil d'amarrage selon la revendication 1, caractérisé en outre en ce que le dispositif de détection comprend :

un circuit (56) destiné à transmettre de l'énergie électrique au dispositif à bobines d'induction électrique (52, 54) à une fréquence prédéterminée, à détecter les variations d'énergie électrique transmise qui peuvent être attribuées à des variations de la position verticale du collier (24) par rapport au dispositif à bobines d'induction électrique, et à créer en conséquence un signal de sortie (80, 82) indiquant l'entrée du collier dans le tronçon de raccord de colonne.

5. Appareil d'amarrage selon la revendication 4, caractérisé en ce que le signal de sortie (80, 82) est en outre représentatif de la position verticale du collier (24) dans le tronçon de raccord de colonne (14a) et crée en conséquence un signal de sortie (84) qui est représentatif de la position verticale.

6. Appareil d'amarrage selon la revendication 4 ou 5, caractérisé en ce que le signal de sortie (80, 82) est en outre représentatif du sens de déplacement vertical du collier (24) dans le tronçon de raccord de colonne (14a) et crée en conséquence un signal de sortie (96, 98 représentatif du sens de déplacement vertical.

7. Appareil d'amarrage selon l'une des revendications 4 à 6, caractérisé en ce que :
le dispositif à bobines d'induction électrique (52, 54) comprend plusieurs bobines d'induction électrique disposées chacune dans une partie axiale différente du tronçon de raccord de colonne.

8. Appareil d'amarrage selon l'une quelconque des revendications 4 à 7, caractérisé en ce que :
le circuit (56) est destiné à détecter les déphasages de l'énergie électrique fournie au dispositif à bobines d'induction électrique (52, 54), les déphasages étant provoqués par les variations de la proximité axiale du collier (24) au dispositif à bobines d'induction électrique.

9. Appareil d'amarrage selon l'une quelconque des revendications 4 à 8, caractérisé en ce que le circuit comprend :
un générateur de fréquence (58) raccordé au dispositif à bobines d'induction électrique afin qu'il transmette de l'énergie électrique à ce dispositif, et
un comparateur de déphasage (60, 62) raccordé entre le générateur de fréquence (58) et le dispositif à bobines d'induction électrique afin qu'il détecte les déphasages de l'énergie électrique transmise et crée en conséquence des signaux de sortie (80, 82) qui indiquent en combinaison l'entrée du collier (24) dans le tronçon de raccord de colonne (14a), la position verticale du collier dans le tronçon de raccord de colonne et le sens de déplacement vertical du collier dans le tronçon de raccord de colonne.

10. Appareil d'amarrage selon la revendication 4, caractérisé en ce que :
le dispositif à bobines d'induction électrique comprend une première bobine d'induction électrique (52) entourant à l'extérieur le tronçon de raccord de colonne, et une seconde bobine d'induction électrique (54) entourant à l'extérieur le tronçon de raccord de colonne et placée au-dessous de la première bobine d'induction électrique.

11. Appareil d'amarrage selon la revendication 10, caractérisé en ce que :
le tronçon de raccord de colonne (14a) est formé d'un matériau pratiquement non magnétique.

12. Appareil d'amarrage selon la revendication 11, caractérisé en ce que :
le tronçon de raccord de colonne (14a) est formé d'un matériau d'acier inoxydable.

13. Appareil d'amarrage selon la revendication 4, caractérisé en outre en ce qu'il comprend :
un circuit de sécurité (figures 4A, 4B) destiné à créer un signal de verrouillage à la suite de l'entrée du collier (24) dans le tronçon de raccord de colonne, le signal de verrouillage pouvant être utilisé pour l'inhibition automatique du fonctionnement des dispositifs de déplacement sélectif du train de tiges.

14. Appareil d'amarrage selon la revendication 13, caractérisé en ce que :
le circuit de sécurité (figures 4A, 4B) peut en outre fonctionner afin qu'il détecte la condition d'ouverture-fermeture de chacune des vannes supérieure et inférieure d'éruption (26, 28) et crée un signal de verrouillage qui peut être utilisé pour inhiber le fonctionnement du dispositif de déplacement sélectif du train de tiges (12) dans le cas où l'une des vannes supérieure et inférieure d'éruption est à un état erroné d'ouverture-fermeture.

15. Appareil d'amarrage selon la revendication 13 ou 14, caractérisé en ce que :
l'appareil d'amarrage comporte en outre une vanne de purge (32) raccordée au tronçon de raccord de colonne (14a) et destinée à évacuer l'intérieur à la pression atmosphérique, et une conduite d'égalisation (34) raccordée entre le tronçon de raccord de colonne et une partie du raccord de colonne (14) placée au-dessous de la vanne inférieure d'éruption, la conduite d'égalisation ayant une vanne d'égalisation (36) placée dans cette conduite et destinée à mettre sélectivement l'intérieur du tronçon de raccord de colonne à la pression du puits, et
le circuit de sécurité (figures 4A, 4B) est en outre destiné à détecter l'état d'ouverture-fermeture de chacune des vannes de purge (32) et d'égalisation (34) et à créer un signal de verrouillage qui peut être utilisé pour inhiber le fonctionnement du dispositif de déplacement sélectif du train de tiges (12) lorsque la vanne de purge ou la vanne d'égalisation est dans un état ouvert-fermé erroné.

16. Appareil d'amarrage selon l'une quelconque des revendications 1 à 4, caractérisé en outre en ce qu'il comprend :
un dispositif (84, 92) de détection et d'enregistrement du nombre de colliers (24) passant dans le tronçon de raccord de colonne dans un sens donné verticalement, si bien que la longueur du train de tiges (12) placé au-

dessous de la vanne inférieure d'éruption peut être contrôlée avec précision.

17. Appareil d'amarrage selon l'une quelconque des revendications 1 à 4, caractérisé en ce qu'il comprend en outre :

une vanne de purge (32) raccordée au tronçon de raccord de colonne et destinée à évacuer celui-ci à la pression atmosphérique,

une conduite d'égalisation (34) faisant communiquer les parties internes du tronçon de raccord de colonne et une partie du raccord de colonne (14) disposée au-dessous de la vanne inférieure d'éruption,

une vanne d'égalisation (36) placée dans la conduite d'égalisation et destinée à élever sélectivement la pression dans le tronçon de raccord de colonne afin qu'elle atteigne celle du sondage du puits, et

un dispositif (86) destiné à donner une indication visuelle à distance des conditions d'ouverture-fermeture des vannes supérieure et inférieure d'éruption, de la vanne de purge et de la vanne d'égalisation.

18. Appareil d'amarrage selon la revendication 17, caractérisé en ce que :

les vannes supérieure et inférieure d'éruption, la vanne de purge et la vanne d'égalisation sont commandées chacune hydrauliquement par un dispositif à poignée (26b, 28b, 32b, 36b), et

le dispositif destiné à donner une indication visuelle à distance comporte un dispositif (100-106) destiné à détecter la position de chacun des dispositifs à poignée, un dispositif (108-112) destiné à détecter les pressions internes du tronçon de raccord de colonne, d'une partie de raccord de colonne disposée au-dessus de la vanne supérieure d'éruption (26), et d'une partie du raccord de colonne placée au-dessous de la vanne inférieure d'éruption (28).

19. Procédé de détection de l'entrée d'un joint de train de tiges raccordant un collier (24) dans un tronçon longitudinal (14a) de raccord de colonne (14) disposé entre des vannes supérieure et inférieure d'éruption (26, 28) pendant un déplacement axial du train de tiges dans le raccord de colonne, le procédé comprenant les étapes suivantes :

la fixation d'une bobine d'induction électrique (52, 54) au tronçon longitudinal de raccord de colonne (14a) entre les vannes supérieure et inférieure d'éruption (26, 28),

la transmission d'énergie électrique (64) à la bobine d'induction électrique,

la création, par le collier (24), lorsqu'il pénètre dans le tronçon longitudinal de raccord de colonne (14a), d'un déphasage de l'énergie électrique, et

la détection du déphasage et la création en conséquence d'un signal de sortie (80, 82) représentatif de ce déphasage.

20. Procédé selon la revendication 19, caractérisé en outre en ce que :

l'étape de fixation d'une bobine d'induction électrique au tronçon longitudinal de raccord de colonne comprend l'étape de fixation de bobines supérieure (52) et inférieure (54) d'induction électrique au tronçon de raccord de colonne (14a) entre les vannes supérieure et inférieure d'éruption (26, 28) et la transmission d'énergie électrique aux bobines d'induction électrique, et

l'étape de détection du déphasage comprend la détection des déphasages (60, 62) de chacune des bobines d'induction électrique (52, 54) et la création en conséquence de signaux de sortie (80, 82) qui indiquent en combinaison l'entrée du collier (24) dans le tronçon de raccord de colonne (14a), la position verticale du collier (24) dans le tronçon de raccord de colonne (14a), et le sens de déplacement vertical du collier (24) dans le tronçon de raccord de colonne (14a).

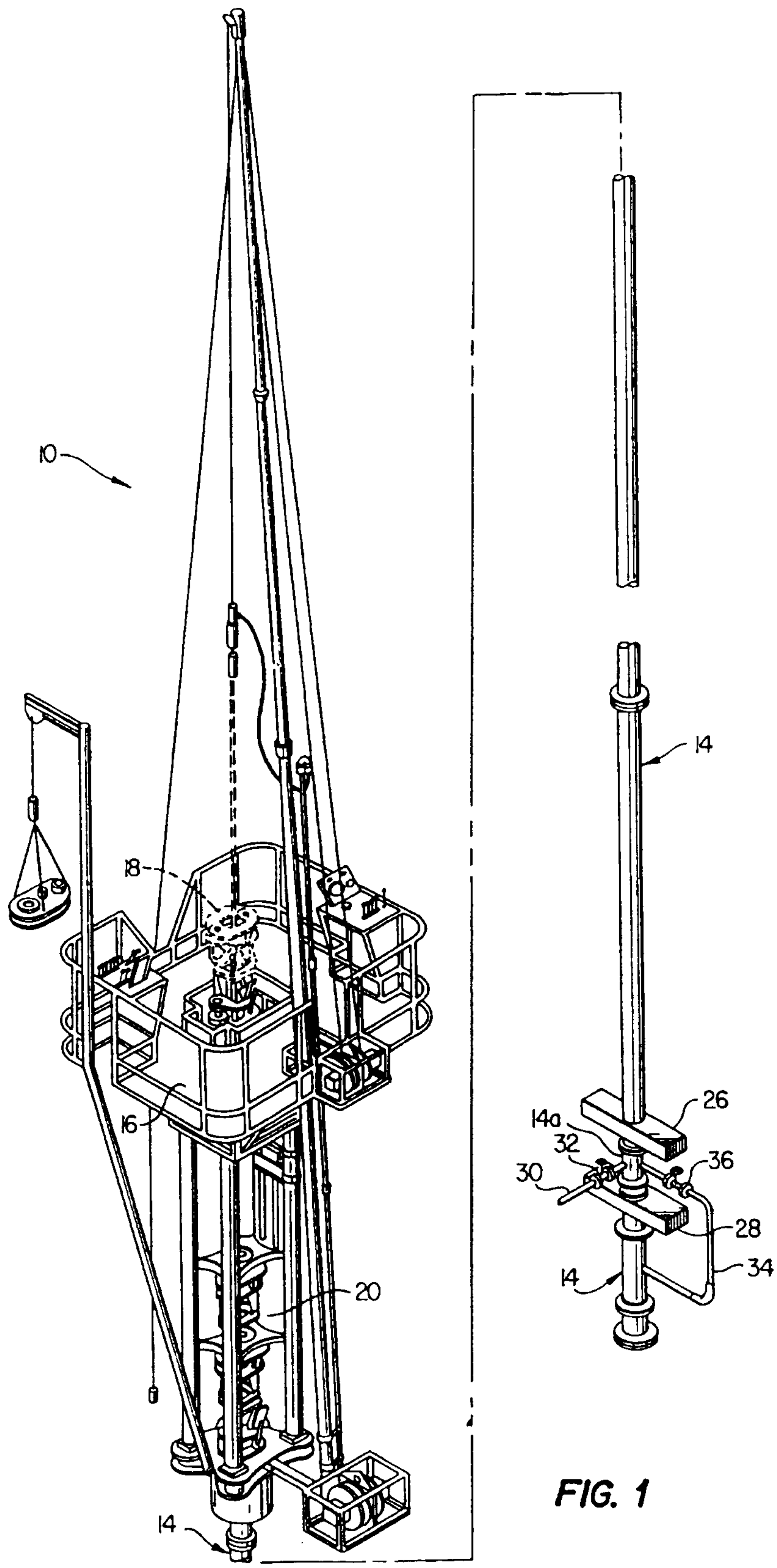

FIG. 1

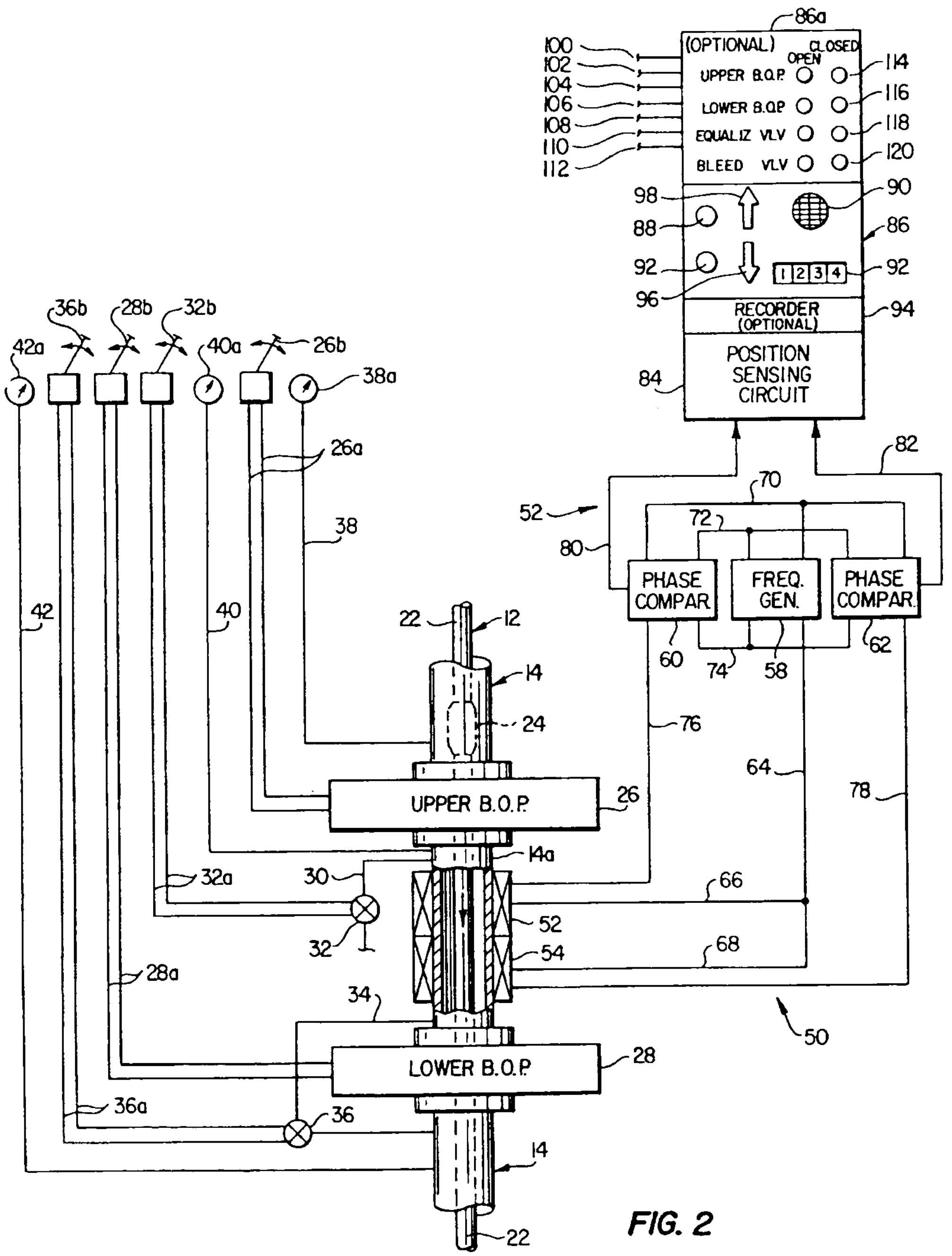
(OPTIONAL)
OPEN
CLOSED
UPPER B.O.P.
LOWER B.O.P.
EQUALIZ VLV
BLEED VLV
1 2 3 4
RECORDER (OPTIONAL)
POSITION SENSING CIRCUIT
PHASE COMPAR.
FREQ. GEN.
PHASE COMPAR.
UPPER B.O.P.
LOWER B.O.P.

FIG. 2

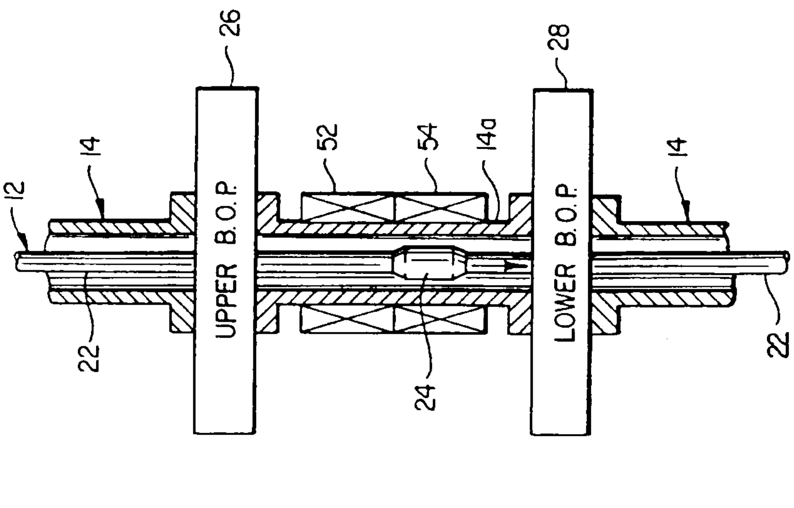

FIG. 3C

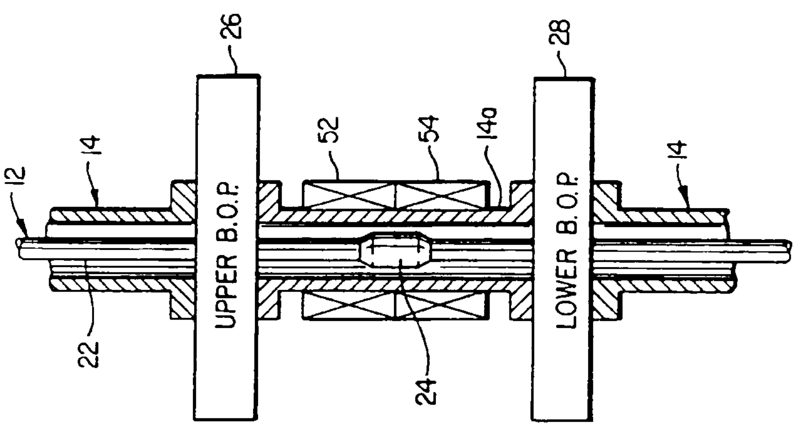

FIG. 3B

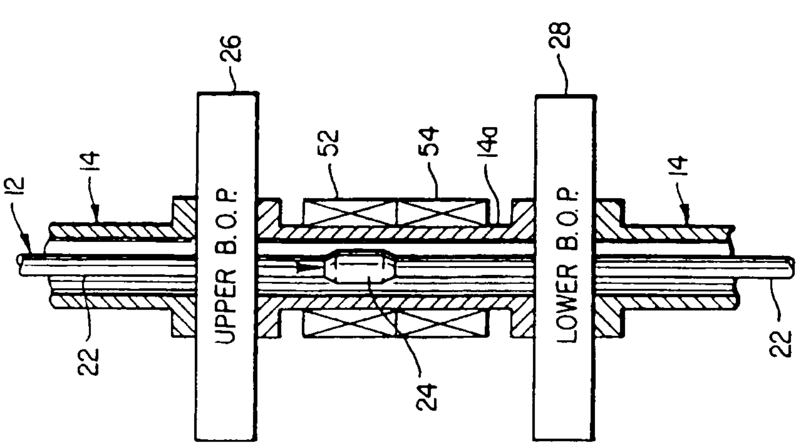

FIG. 3A

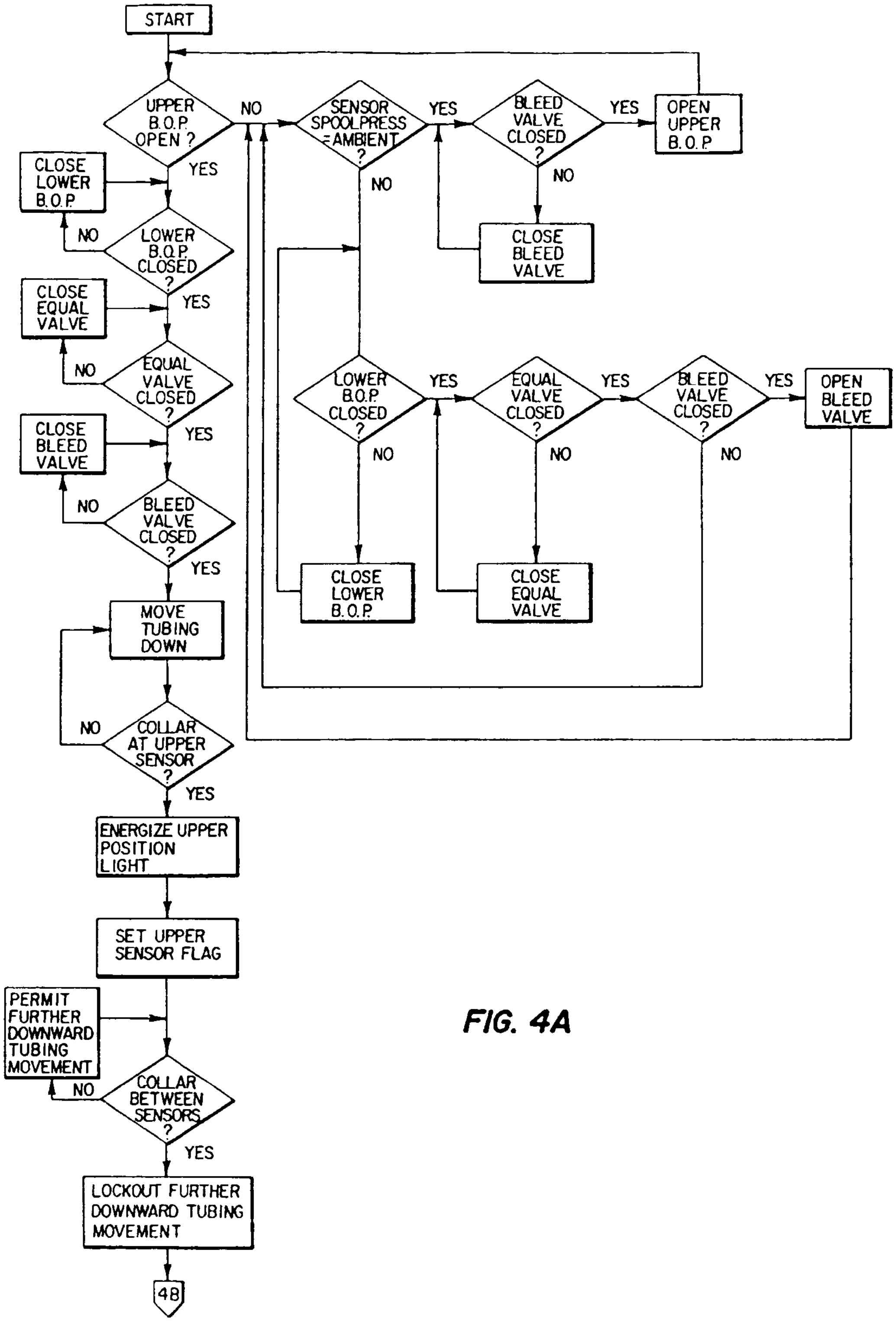
START
UPPER B.O.P. OPEN ?
NO
YES
SENSOR SPOOLPRESS =AMBIENT ?
YES
NO
BLEED VALVE CLOSED ?
YES
NO
OPEN UPPER B.O.P.
CLOSE BLEED VALVE
CLOSE LOWER B.O.P.
LOWER B.O.P. CLOSED ?
NO
YES
CLOSE EQUAL VALVE
EQUAL VALVE CLOSED ?
NO
YES
CLOSE BLEED VALVE
BLEED VALVE CLOSED ?
NO
YES
LOWER B.O.P. CLOSED ?
YES
NO
EQUAL VALVE CLOSED ?
YES
NO
BLEED VALVE CLOSED ?
YES
NO
OPEN BLEED VALVE
CLOSE LOWER B.O.P.
CLOSE EQUAL VALVE
MOVE TUBING DOWN
COLLAR AT UPPER SENSOR ?
NO
YES
ENERGIZE UPPER POSITION LIGHT
SET UPPER SENSOR FLAG
PERMIT FURTHER DOWNWARD TUBING MOVEMENT
COLLAR BETWEEN SENSORS ?
NO
YES
LOCKOUT FURTHER DOWNWARD TUBING MOVEMENT
4B

FIG. 4A

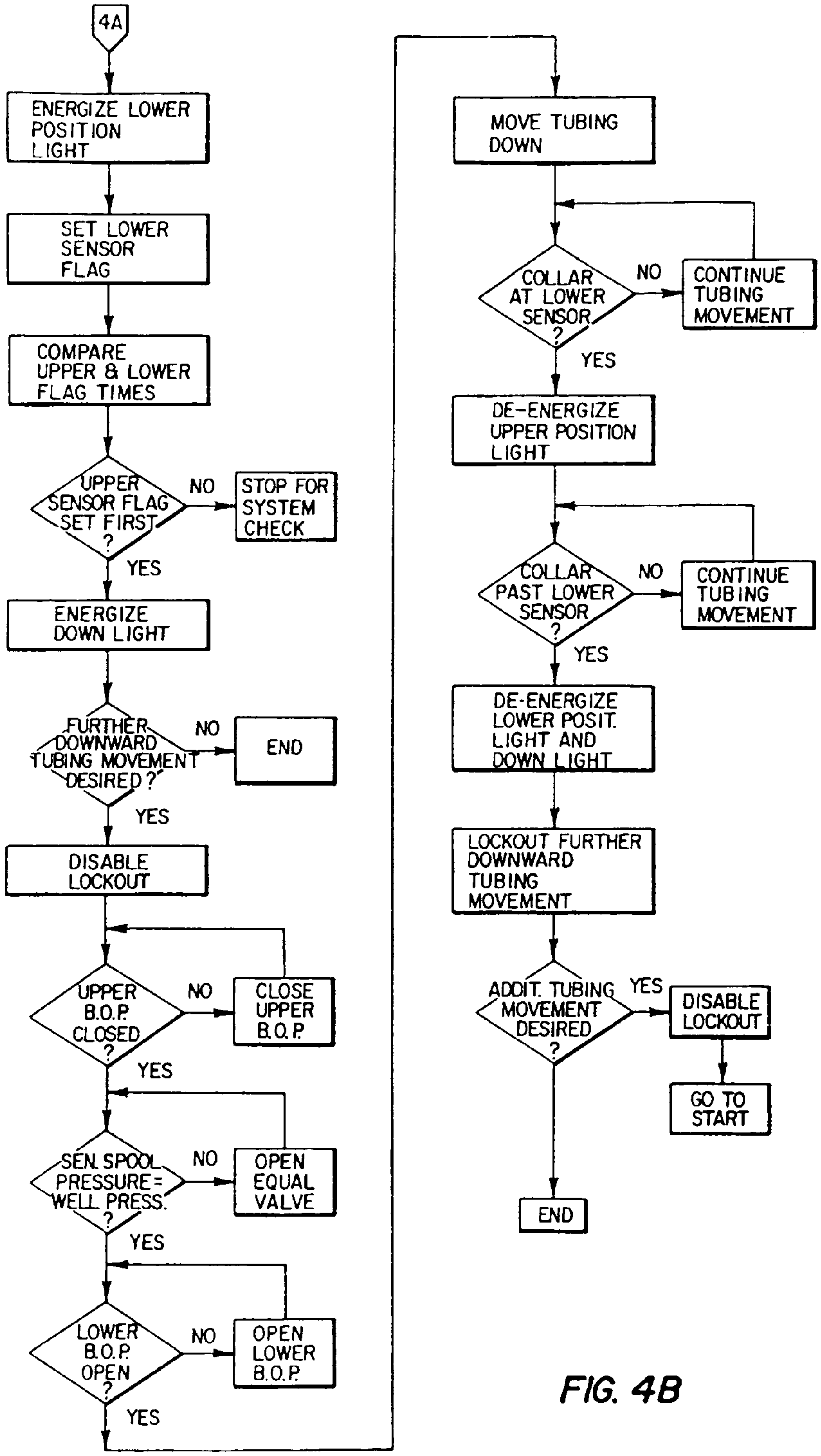
4A
ENERGIZE LOWER POSITION LIGHT
SET LOWER SENSOR FLAG
COMPARE UPPER & LOWER FLAG TIMES
UPPER SENSOR FLAG SET FIRST ?
NO
STOP FOR SYSTEM CHECK
YES
ENERGIZE DOWN LIGHT
FURTHER DOWNWARD TUBING MOVEMENT DESIRED ?
NO
END
YES
DISABLE LOCKOUT
UPPER B.O.P. CLOSED ?
NO
CLOSE UPPER B.O.P.
YES
SEN. SPOOL PRESSURE = WELL PRESS. ?
NO
OPEN EQUAL VALVE
YES
LOWER B.O.P. OPEN ?
NO
OPEN LOWER B.O.P.
YES
MOVE TUBING DOWN
COLLAR AT LOWER SENSOR ?
NO
CONTINUE TUBING MOVEMENT
YES
DE-ENERGIZE UPPER POSITION LIGHT
COLLAR PAST LOWER SENSOR ?
NO
CONTINUE TUBING MOVEMENT
YES
DE-ENERGIZE LOWER POSIT. LIGHT AND DOWN LIGHT
LOCKOUT FURTHER DOWNWARD TUBING MOVEMENT
ADDIT. TUBING MOVEMENT DESIRED ?
YES
DISABLE LOCKOUT
GO TO START
END

FIG. 4B